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ABSTRACT

This paper deals with research on the development of infants' ability to perceive invariant features of things and the relation of objects to both the spatial layout of the infants' environment and to themselves. Basic assumptions regarding the perception of invariance are discussed and a theoretical view of the role of motion in the development of invariance perception is described. Two types of continuous change from which infants can extract information about invariance are identified: (1) transformations in which the perspective of solid objects changes indicating object rigidity and (2) deformations in which the shape of objects changes, indicating object elasticity. Three experiments are described in which the information extracted by infants from these two types of changes was examined. Subjects in these experiments ranged in age from 3- to 5-months of age and a habituation-dishabituation paradigm was employed. Results of these experiments were interpreted as showing that infants at 3 months are capable of picking up two kinds of invariant properties within an event: (1) information specifying shape of an object while the object is in continuous and even changing motion; and (2) information specifying a type of motion when the objects undergoing motion are different shapes. (JMB)

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The Ecological Optics of Infancy: The Differentiation of Invariants Given by Optical Motion*

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What I want to talk about today is the early development of the perception of events. In his presidential address last year, Gordon Bower said that "how people understand events in the world should be a psychologist's main concern." I am in hearty agreement with that statement; but since I have been mainly concerned with the perceiving of things as they are happening, and since I have a conviction that the way to understand a psychological phenomenon is to study its development, I have begun at the beginning. How early does an infant perceive a simple event going on before his eyes? In what way does he perceive it? Is it merely a sensory impression of a change? Or does he get some information about the spatial layout and the objects that furnish it? Do they specify something invariant for him? Do they afford knowledge that is potentially useful for his adaptation to the world?

In spite of the recent flood of investigations of cognitive development in infancy, there has been a dearth of attempts to study perceiving by infants of invariant features of things and of the relation of objects to the spatial layout and to themselves. The important kinds of information for an infant include knowledge about ongoing events, about the spatial

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layout, and about objects (like other people) that afford something useful for him. Invariant aspects of these classes of information have special adaptive utility; for example, floors and walls that retain their apparent stability rather than shrinking or expanding as the observer moves; and objects that keep their identity under various changes like occlusion, rotation, and shifting location.

Invariance can best be extracted from change--from transformations presenting at the same time change and non-change. As adult human beings, we know that the underlying layout of the world remains stable however we sweep our eyes over it, or change position so as to create a totally different set of perspectives projected to our eyes. A gate can swing back and forth changing its projection to the retina continuously from one perspective shape to another, but an adult observer unfailingly perceives it as rigid and rectangular, because the information for these properties is present in the transformations over time—not in any one of them alone, but in the continuous series (Gibson and Gibson, 1957). The continuous cyclic optical transformation going from one end-position to another and back again has abstract, rule-like information that specifies the invariant rectangular shape of the gate. The rule that describes the transformations generates the "true" shape, as no arrested moment in the event could. The observer can perceive the event too, the swinging back and forth of the gate. It tells him when the gate is open or closed.

We perceive another person as the same person whether he is sitting still, talking, laughing, eating, and so on. The optical projection of the face, for example, shifts with changing expressions, but it is seen as the same face. We perceive causal relations or other kinds of pre-

dictable relations in an event such as chasing or bumping despite a continuous flux of pattern. We perceive objects as having constant sizes and shapes, despite variable distances from us on different occasions and varying angles from which we view them. Things in the world, and the viewer himself, are as often moving as not, but this is not a handicap for the attending seeker of information; on the contrary, there is information in the transformations that the movements give rise to.

All these examples are testimony to the observer's ability to locate himself in a stable world furnished with objects of constant proportions and persisting identity in an objective spatial layout. Voices maintain their identity, despite variable distance or muffling by a cold in the speaker's head; events are perceived as having internal predictability, and meaningful kinds of internal relations.

Is it possible to investigate the development of this seemingly sophisticated kind of perceiving in young infants? The project may be overly ambitious but I am taking the risk, beginning by stating a few basic assumptions. First, what is an event? One definition (Gibson, 1977, in press) refers to an event as a "change in the surface layout" that has a number of interesting properties. There is change over time, but there is continuity in that change. Something changes and something persists. There is unity, or we should not refer to an event. What provides the unity varies from one event to another, but it is often conferred by an actor or an object that changes something or is changed. An event typically involves motion. An event may be reversible or symmetrical. An event may be long and contain embedded subordinate events.

The smallest units would be at the bottom of a kind of event hierarchy.

Consider, as an example, a game of peekaboo. The game itself is an event with a nice, regular structure that involves reiteration of actions of an agent and a recipient (who may, in a more complicated game, change roles, thus producing more elaborate embedding). The overall event is analyzable into a number of embedded events. For example, a mother begins by looking at her infant and waiting until he is watching her. Then she covers her eyes, and says "where's mommy?" The infant watches, possibly with an expression of suspense or anxiety. The mother uncovers her eyes, smiling, and says "Hi, baby, peekaboo." The infant expresses surprise and laughs, and the whole sequence begins again. (Bruner, Jolly, & Sylva, 1976). Consider the baby as recipient. The sub-events that he observes are many and can be analyzed into very small units, such as a motion of the mother's hand as she begins to cover her eyes, thereby occluding a sizeable part of her facial structure. There is gradual deletion of facial features as the hands move over her face.

I think that analysis of the internal structure of an event is very important. I suspect that comprehension of the total superordinate and subordinate structure of even a simple game like peekaboo, while it develops pretty early (about 8 months) is preceded by perception of some of the smaller events like eye-covering and uncovering, which seem to be interesting in themselves. I think that these small units are not analyzable further in any meaningful way and that they are themselves perceived as events, not integrated from static images. They often involve a progressive change in the relation of one object to another (e.g., the hand covering the eyes) or of one object to the larger spatial layout.

It seems to me that experience of progressive change in an event is the foundation for essential knowledge of the persisting properties of objects and the places those objects occupy. It is these properties of the world that we must put our trust in and act upon, and thus must somehow find out about. Some of these persisting properties can only be discovered by experiencing change. Observable changes as an object moves about in his immediate neighborhood are provided very abundantly for an infant. His mother enters the room and moves toward his crib, projecting an ever large image on the baby's retina, occluding more and more of the background as she looms over him to see if he is content. If he is, she moves away again, now reversing the pattern and progressively revealing more of the room as she retreats. This is a very nice reversible event from which to learn about constancy of an object's properties—its shape, its size, and its continuity over change.

Reversible events provide information for invariance of all kinds--constancy, identity, conservation, and so on. Piaget has often discussed the importance of reversibility, but he speaks of reversible operations in the individual perceiver (cognizer, in his book). I think the events themselves provide the information. What the person must do is not perform a reversible operation, but discover the information for invariance that continuous, progressive transformations in the optic array over time can give him.

Does he put an event together by assimilating static snapshots into a scheme, and then integrate schemes gradually into even higher order schemes, finally combining schemes from different sensory modes (visual, kinaesthetic, etc.)? Does he construct reversible groups by imposing his own actions on sensory experience, as Piaget would have us believe? Or does

he categorize experience by the application of logical processes of inference, structuring the world by deductive inference rather than action as others (Bruner, 1957; Bryant, 1974; Butterworth, 1976) would have us believe? According to either of these interpretations, when an object moves, the observing infant presumably must connect successive momentary static positions of the object in order to identify that object as the same from instant to instant. And that is what I would deny.

Motion thus seems to be the critical case for study if we are to know how one comes to perceive (or to know, if you prefer that term) the invariant properties of things and layout. Consequently, I have chosen it for my investigations with young infants, and I have adopted a radical theoretical view. According to that view, in learning about persisting properties of things, the infant does not integrate snapshots with actions, nor categorize inferentially the momentary successive positions of a moving object; but rather he extracts the invariant information given over a continuous transformation. The information is given only over time, and the infant must eventually (the sooner the better) perceive it thus.

Few of us would expect the very young infant to pick up all the information in a longish event sequence like a peekaboo game. But we can quite sensibly ask about perception of simple events; when they are differentiated, and what ones are differentiated. We might expect that there would, first, be differentiation of types of events that afford useful knowledge about contrastive properties of things. One such type is the movements that are characteristic of rigid objects as they rotate around, or move to and fro. The gate swinging back and forth, attached to its vertical gatepost, is an example. Its movements elicit a set of continuous

optical changes describing a systematic set of internal relations referred to as perspective transformations. Even when an image of such motion is projected on a two-dimensional screen, as may be done with a shadow-casting device, we do not perceive an elastic substance diminishing and enlarging (a shrinking-stretching motion characteristic of a pliable substance); we perceive a rigid object swinging back and forth in three dimensions. Not all motions that specify rigidity of an object are describable as perspective transformations in which the optical texture undergoes continuous foreshortening, but all rotations in depth, around any axis, are of this kind, and the rule that specifies the changing optical information is the same for all axes. Optical motions that specify rigidity of an object are also yielded by movement to and fro on an axis perpendicular to the observer, or by rotation in the frontal plane. In all these cases, the elements of surface texture "all move together when they move" maintaining systematically the relationships of an unchanging structure.

A second type of event involving movement is deformation, which would be characteristic of an elastic substance. An example would be stretching a piece of rubber and then letting it return to its original shape. Another example would be a human face changing from a relaxed expression to a broad smile of welcome and then relaxing again, or a sponge being squeezed and then expanding to its original shape. A change of shape, or deformation is involved. Elements of surface texture are displaced with respect to one another to give an appearance of structural change. But for elastic substances these changes are reversible (unlike breaking a rigid object such as a glass or an egg). A reversible deformation thus

provides information for a non-rigid substance--the transformed object is elastic, pliable, and quite possibly animate.

These two contrasting events--motion specifying rigidity and motion specifying elasticity--were chosen for an experiment with young infants, because they convey, if the information is picked up, adaptive knowledge about substances of things with which we often come in contact. Rigid things are hard and unyielding and can even hurt us if we bump into them or they bump into us. But deforming things are potentially yielding, possibly even animate and cuddly.

In the first experiment[1] that I will describe, we asked whether infants at five months of age could differentiate these two types of events. I mean types, not just two specifically different events. Two particular motions might be discriminated on some highly specific basis without providing evidence that the observer has detected information about an invariant property of a class of objects. We decided, therefore, to ask whether several different motions all specifying rigidity would be perceived by the infants as conveying invariant information. The strategy of the experiment was to habituate the infant to three of four different rigid motions, and then to test for dishabituation to a fourth, non-habituated

[1]All the experiments that I will mention were performed with graduate student colleagues, who contributed their ideas in planning, designing, and analyzing the experiments as well as carrying them out. I am especially indebted to Cynthia Owsley, Arlene Walker, and Jane Megaw-Nyce. I am indebted also to the Susan Linn Sage Fund of Cornell University and to NSF Grant #76-14942 for partial support of the research.

one and also to a reversing deformation. If the infant showed dishabituation to the deformation, but not to the fourth rigid motion, we would infer that he perceived an invariant property that all four rigid motions revealed, but that the deformation did not. The same object had to undergo the different motions in all cases, so we chose a sponge rubber shape stiff enough to be made to display rigid motion, but sufficiently yielding to permit deformation. The motions were cyclic, so that reversibility might be evident.

Before I explain a few details of the experiment, I would like to show a short film which makes clear the proccdure, the motions, and the objects that we used. Objects for a second experiment are also illustrated in the film.

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show film
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In the first experiment, we used only the circular object, but all of the motions--three types of rotation and a back-and-forth motion for the four rigid transformations, and a squeezing motion for the deformation. Each baby had a very brief pretest with one rigid motion and the deforming motion to determine whether a preference for one or the other existed; there followed a course of habituation to whichever of the three rigid motions did not appear in the pretest; and finally there were four dishabituation tests, two for each of the pretest motions. The slide summarizes the design.

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slide
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A criterion of habituation was set at one-half the length of the fixation time on the first or second fixation, whichever was longer.

All three rigid motions were continued consecutively in a series of "trials" until criterion was reached. A trial lasted until a baby looked away for two seconds, after which a new trial began, with one of the other motions. When the criterion had been met for all three motions, the post-test began. Half the Ss saw the fourth rigid motion first, half the deformation.

Log transformations were performed on looking times to normalize the distribution, and then we plotted backward habituation curves (Cohen & Gelber, 1975). A single point on the habituation curve represents a three-motion sequence (the mean of fixation times for all three habituated motions on their last presentation, then reading backwards the next to last, and so on). The slide depicts the curve for the Ss who saw deformation first in the pre-and post-tests. There was greater dishabituation to the deformation than to the fourth rigid motion, and the difference was maintained on the second presentation. The next slide presents the data for Ss who saw the fourth rigid motion first in the pre- and post-tests. Again the deformation was fixated longer and the increase persisted.

An analysis of variance was performed which utilized as a within-subject factor a comparison of two difference scores: that is, the duration of the first look on deformation minus the duration of the last look on habituation, compared with the analogous difference in duration between the first look at the fourth rigid motion minus the last look on habituation. There was a significantly larger increase to the deformation as compared to the fourth rigid motion ($p < .005$). No other factor (e.g., order or sex) was significant.

It might be argued that deformation, possibly owing to its similarity to animate motion, is inherently more interesting. However, comparison of the pretest scores showed no difference in looking time for the two. On the first look, the babies were equally interested in both of them. It was also possible that the overall effect might have been due to the over-riding influence of a single one or perhaps two of the rigid motions. But an analysis of variance with the four rigid motions as factors yielded no significant differences.

We concluded that five-month old infants not only perceive a difference between cycles of rigid motion and cycles of deformation, but that they are able to extract invariant information from the three different rigid motions, as shown by the fact that they can identify a fourth one.[2] But they distinguish a new property when the object is deformed.

It would be awkward, it seems to me, to interpret these results in a theoretical framework of integrating static snapshots. It would appear, rather, that the infants were perceiving an object composed of a rigid substance when it underwent one kind of motion, and that they distinguished this property of rigidity from non-rigidity when the type of motion was changed. This interpretation leads to further questions. Do infants rely primarily on information from motion to identify objects at an early age, as these results might be taken to imply? Can these infants distinguish shapes of objects too? And if they distinguish shapes, can they do so when the objects are presented only in motion? Can they identify a stationary object if it has been observed only when it was in motion?

[2] That adults are capable of such a distinction was demonstrated by Fieandt and Gibson (1959).

Do they only perceive the event, or do they also perceive an object that persists despite changes that occur within the event? That is in fact the question I started with, and it is addressed in the next two experiments.

Experiment II asked whether infants can distinguish one shape from another if the first shape has been observed only when undergoing motion, and even when it has been observed undergoing more than one kind of rigid motion. The second object, of a different shape, would be presented undergoing the same two motions. If the two objects are distinguished under these conditions, then an invariant property (shape of the object) has been detected within an event.

Accordingly, we presented one object, either a circular one, a triangular one, or a square one for habituation. The object was presented successively undergoing two rigid motions, chosen from the earlier set (except for the looming motion). Following habituation to both motions, two dishabituation trials followed, continuing the same two motions, but substituting a new shape. To decide whether the new shape was distinguished from the old one, we ran a control group of infants that was continued past criterion with no change of shape. Our subjects this time averaged three months of age.

Again, we plotted backward habituation curves for both groups. As the slide shows, there was dishabituation to the new object. The difference between the no-change control group and the shape-change group on the first trial after reaching the criterion of habituation was significant ($p < .01$). It is interesting that looking time dropped again on the second post-habituation presentation. The motions that continued were after all habituated and both continued to specify rigidity.

Three month old infants can, it seems, distinguish two objects that they have never seen in a static pose, such as a triangular shaped one, a square one or a circular one. In other words, the shape of an object was detected despite continuous and changing motion. The inference I draw is that detection of shape as a constant property does not depend on "arrested images," even in three-month old infants.

Now, we wondered, could infants distinguish types of motion, as in Experiment I, and detect an invariant property having to do with the type of motion, when those motions were presented with varying objects? In Experiment III, we presented the infants (again three months old) with an habituation series that alternated two differently shaped objects, both always displayed undergoing the same rigid motion. Habituation was carried to a criterion, as usual. Following habituation, one-third of the babies were presented with a new rigid motion, but with no change of object. A second group was presented with a motion of deformation, but with no change of object (the two differently shaped objects were presented in succession, as during habituation, to yield two dishabituation tests). The third group, a control group, continued the habituation procedure with no change of any kind.

If an infant perceived the two differently shaped objects undergoing a rigid motion as having a common property, rigidity, he should not dishabituate when the motion was changed, if it were changed to another motion signaling the same property. He should dishabituate, however, if the motion were changed to one that signals a different property, elasticity.

The backward habituation curves (see slide) bear out these expectations. The group that was shifted to a deformation showed a sharp rise in looking time. The group that was shifted to a new rigid motion showed

a slight rise. The control group showed no rise. The difference in looking times on the first post-habituation test between the deformation group and the control group was very significant ($p < .001$). The difference between the new rigid motion group and the control group was not significant. The difference between the deformation group and the new rigid motion group was significant ($p < .01$), confirming the result of Experiment I (with younger infants and only one motion for habituation).

We infer from these experiments that infants at 3 months are capable of picking up two kinds of invariant properties within an event: 1) information specifying shape of an object while the object is in continuous and even changing motion; and 2) information specifying a type of motion when the objects undergoing motion are different shapes. Two kinds of information about objects must then be picked up at once. Despite changes during the habituation sequence, if information for an invariant property persists it is detected. Nor are the changes themselves meaningless, if the infant is "asked" about them properly.

These results do not seem to us easily explained by either a "snap-shot" theory that hypothesizes operations on figural, static impressions nor by a deductive inference theory, since that is also based on momentary elementary sense-impressions. But it is difficult to perform a critical experiment that will demonstrate detection of invariants in continuous motion as the only conceivable hypothesis. We decided to move on to another quite risky experiment that, given positive results, would seem to us to converge on the same hypothesis.

Consider, for a moment, what an <u>object</u> is. An object is a closed surface, tangible and many-sided. It takes up a region of space. It

may be detached, so that if it rests on a surface it can be picked up and moved. It may be attached to a surface, but in that case, an observer can walk around it and view it from a number of perspectives. How do we know the shape of an object, visually? Or can we? An object does not have a form, in the sense of a single static image, projected on a screen for instance, or drawn on a piece of paper. We look at it with two eyes and a moveable head, and so we see around quite a bit of even a motionless object. If it rotates, or if we move around it, we see even more. One "face" or "aspect" does not describe its shape, unless the object happens to be perfectly symmetrical on every axis, like a sphere. What then is the information for the shape of an object?

I have already mentioned two constructivist theories, one involving action upon and coordination of views (and other modes of sensation such as tactual as well) into a scheme. The other theory does not require action, but invokes inference from successive sensory presentations.

My own view is that shape of an object is described by what my husband, James Gibson (1973) and John Hay (1966) termed "formless invariants." As we perceive continuous transformations of an object undergoing motion (no matter what the cause of the motion) the description of the transformations is the description of the object.[3] It is not a

[3]cf. Cassirer (1944): "It is not possible to realize the thought of a perceptual object - the intended "object" of perception - in perceptual consciousness by a mere image; it can only be represented by a rule . . . . The rule may, in simple and exact terms, be defined as that group of transformations with regard to which the variation of the particular image is considered" (p. 22).

scheme stored as a single or even a number of two-dimensional representations. So far as I am aware, no one supposes that (although it is unclear what a "scheme" is like), and we have ample evidence, as far back as Michotte's (Michotte, Thinès, & Crabbé, 1964) demonstrations of amodal perception that we perceive more than what is momentarily given by sensations.

Does one have to witness a complete family of transformations, in the sense of a 360° motion around every axis, in order to know the shape of an object? If it is the invariants that give the description of an object, that should not be necessary. How extensive the rotation need be to "know" the shape depends on the object, but even an object with a quite complex surface layout will have its shape described by less than a total rotation. Witnessing the transformations should generate, potentially, recognition of some unexposed aspects. This implication of an invariance theory of shape perception was the basis for Experiment IV.

The question was, can a static object be identified when it has been viewed only while moving through a series of transformations? More particularly, can the object be identified when it is posed so as to present an aspect that was <u>not actually viewed</u> during the display of the moving object? We predicted that infants familiarized with an object while it rotated through a restricted arc would still identify that object when it was displayed at rest, presenting an aspect that was not viewed during familiarization. I do not see how a construction theory based on integration of separate views could explain such a result, especially when the perceivers are very young infants and the objects unfamiliar.

There are a number of difficulties in setting up such an experiment. What method, for instance, would let the infant tell us whether or not he

recognized an object as one he had seen before? We began with a procedure that has been used frequently in recent years (Fagan, 1976), usually with pictorial displays (though not always; Gottfried, et. al., 1977). The infant is shown a selected display for a limited time for "familiarization." Following familiarization, a dual display, the original one paired with something new, is presented. If the infant has become familiar with the original one, he will presumably turn his attention to the new one. Length of fixation ("looking time") is monitored for a restricted interval (10 sec. or so). If the infant looks longer at the new member of the pair displayed, he is assumed to have recognized the old one. There are a number of questionable assumptions underlying this procedure, so we included in our experiment a control with stationary presentations that would tell us whether other experimenters' reports of such a finding could be replicated with our objects, subjects, and general procedure.

We chose two pairs of objects that were asymmetrical, or else symmetrical around only one axis. Two are made of styrofoam and two are constructed of sponge rubber, which has a similar visible texture from a short distance away. The objects are white, spotted with red paint to insure greater similarity of texture. The slides show the two shapes used as standards, the "front" or "seen" aspect displayed. They are rotated to produce an "unseen" aspect, and mutilated by amputating a part to produce a "novel" comparison object.

The essential comparisons we wanted to make were between familiarization when the object was presented stationary, in one position, as opposed to moving back and forth through an arc of 140°; and between tests of the object in a previously seen stationary aspect and a previously

unseen stationary aspect. We should find that the infants recognized the seen aspect following a stationary familiarization, such as earlier research would predict on an empirical basis; we might also find that the infants recognized the seen aspect following moving presentations, as well (our own experiments, which I have just described, led us to expect that, although we had not previously conducted a test with a static presentation); finally, we might find that the infants given a static familiarization did not recognize the unseen aspect, while infants given a moving presentation did. This third result, an interaction between static or moving presentation, familiar or novel object, and a seen vs. an unseen test aspect, would be the truly radical result. To win the stakes, so to speak, we have to obtain a specific three-way interaction.

This experiment is being run at present, so whether we will obtain the magic interaction is still a matter for speculation. It is easier by far to work with college sophomores; but in the end, the infants may tell us more about how we obtain knowledge of events, objects, and the properties and affordances of things in the world.

I have referred several times to the "affordances" provided by an object that looks curved vs. sharp, or a substance that looks rigid vs. elastic and spongey. The visual information may be said to provide foreknowledge of how the object or substance will feel when it is explored haptically with the mouth or the fingers. Does the baby know this, when he shows that he can perceive the invariant information about these properties that is given in optical stimulation? In earlier times, most psychologists would have answered no; that a substance, for instance, must be prodded and explored haptically to discover that it is rigid or

yielding. The knowledge obtained haptically would then be associated to the visually perceived invariant to give it "meaning."

I believe that this view is no longer so widespread. The notion that "the hand teaches the eye" has lost ground steadily in the past decade. Active touch is not available to an infant until long after he has gained at least some knowledge from the information about invariants in optical motion. I see no reason why this information is not equally as valid as that obtained haptically. But the question is one for experiment. When an infant has some means of demonstrating an expectation of rigidity or elasticity of a substance, on the basis of optical information, will he do so?

I have not done the relevant experiments, but I have considered how they might be done. Before an infant has developed active touch, he will tend to avoid a looming object that appears to approach him on a collision course. His head thrusts backward and according to some reports, his hands are raised--actions that signify avoidance. Suppose we familiarized one group of infants with an object performing visible movements giving information for rigidity, and another group with the same object undergoing deformation. Now suppose we use the object as a simulated missile in a looming experiment. Will the pressure of the head on a backward thrust be greater in the group exposed previously to rigid motions of the object?

An experiment with the reverse order of visual-haptic experience could also be tried. The infant could be made to feel a yielding, elastic object by means of the experimenter's manipulation of it (unseen of course) in his hand. Or he could be given haptic experience (unseen) with a hard rigid object. An object of similar size could then be visually presented

to him in motion (either rigid or deforming). How long will he look at it? If he can reach, how fast will he reach for it? Are these behaviors related to the earlier experience?

I have thought of more esoteric experiments involving marshmallows and "mouth haptics," but I will let your imaginations work on that, and bring this talk to a close.

And so, to conclude. Many scientists in the recent past have been impressed by Kuhn's (1952) arguments and conclusions in "The Structure of Scientific Revolutions." A paradigm takes hold in a science and bends not only the concepts but the problems that its researchers attack, as long as that paradigm holds sway. It gives way only when it becomes clear that many questions cannot be answered satisfactorily. Perhaps there is recognition by a few that the important questions are not even being asked. Then the revolution is around the corner, only awaiting a new paradigm. Kuhn warned that in his opinion this synopsis did not apply to the social sciences, because they had no paradigms. Yet the analogy, at least, exists for psychology, as I have known it. The first revolution resulted in S-R psychology, already in firm sovereignty when even the oldest of us here were in graduate school. Our mentors were full of conviction, having been through that revolution themselves, and there were few dissidents. Only in the fifties was this approach perceived by many to be sterile, and, however objective, to bypass many of the questions we should be asking about human nature and the human mind (yes, mind).

Many influences combined to produce the dissatisfaction and to frame the new paradigm, which we have been calling cognitive psychology. It

was a revolution, indeed. Everyone talked freely about perception, memory, ideas, and even volition. I leave the details to the historians but the paradigm we wound up with has two pervading themes--information processing and constructivism. The details and the problems that are selected for research are well-known to all of you.

It is this paradigm, with the two themes that have come to characterize it, that I am revolting against (I revolted against the earlier one with the rest of you, of course). What is wrong? The main thing that is wrong is that it too is sterile, and it fails dismally to describe the nature of the environment as it is relevant for man's cognition. It neglects to come to terms with the very information that has to be "processed." But if it were to do so, the word "process" (at least in the sense of construction), would become superfluous. The information offered by the environment that man has evolved to perceive, and to use for purposes of living and adapting to his world cannot be constructed. At best, it would have to be reconstructed—and in that case, from what pieces?

I urge that it is time for the third revolution; that it must begin with a description of the environment that is relevant for human life; that that environment cannot be described in atomistic bits that result in sensations; that events of a size to afford some relevant meaning when they are perceived are the indivisible units; and that integration of arrested images (even if it is possible to explain how the images themselves are integrated) is a totally unsuitable way to conceive of perceptual development in the very world in which a species has evolved.

Let us study the perception of events in infants, then, however difficult it may be, and try to relate it to properly described events

in the infant's world and in the world with which he will have to cope later on. Perhaps it will turn out that some kind of integration is involved when he comes to perceive events on the scope of a drama or a symphony or a game of chess or a war. But we had better not prejudge even that. There is too much to find out first.